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Large Data Sets and the Sublime

The Rocky Mountains, Colorado. Lisa Jevbratt. 2004.

EDITORIAL

by Brett Stalbaum

Moore's Law, Gordon Moore's famous prediction that processing speeds double approximately every 18 months, has proven to be so prescient that it long ago rose past the status of provocative futurist claim to the level of pedestrian cultural assumption. But what has not yet become an accepted cultural assumption is that Moore's law is at least matched, and possibly exceeded by the exponential growth of data to be processed. The relationship between humankind's ability to collect data and to process and understand data is co-exponential: both are exploding. Data sets from genomics, astrophysics, geography, geology, particle physics, climatology, meteorology, nanotechnology, materials science and even the search for ET are producing quantities of data that challenge the technical limits of super computers, distributed computing, grid computing, and superscalar simulation techniques. Even given Moore's law, optical networks, and cheap mass storage, the problem of big data is nevertheless looming larger as our ability to collect data actively competes with our ability to process and digest it.

Computation has already become a nominal, if not tacit assumption in contemporary art practice due to the ubiquitous implementation of computer and communications technologies in all aspects of our emerging global culture. How does big data impinge on the present generation of representational artists who operate under the assumption of a rich computational environment? And what are the emerging aesthetic and conceptual parameters that impinge on the practice of artists who consciously recognize data and coding as the primary expressions of an art practice wherein the notions of "representation" are not limited to narrowly prescribed assumptions regarding a specifically graphical interface and networked distribution as the primary cultural operatives between artist and audience? What other questions arise in an environment where we live in a constant streaming wash of data, and what are the issues surrounding how artists might help interpret both cultural and scientific phenomena?

Lev Manovich raises a particularly interesting issue in his 2002 essay titled "The Anti-Sublime Ideal in Data Art". In it, Manovich identified an aesthetic approach to big data that seeks to interpret large data sets on much the same terms as designers and scientists seek to analyze data; a

pursuit which he describes as the exact opposite goal of romantic art. "If Romantic artists thought of certain phenomena and effects as un-representable, as something which goes beyond the limits of human senses and reason, data visualization artists aim at precisely the opposite: to map such phenomena into a representation whose scale is comparable to the scales of human perception and cognition." He goes on to form a critique of such practice, and raises the question of "How new media can represent the ambiguity, the otherness, the multi-dimensionality of our experience... In short, rather than trying hard to pursue the anti-sublime ideal, data visualization artists should also not forget that art has the unique license to portray human subjectivity – including its fundamental new dimension of being 'immersed in data.'"[1]

> ...what are the emerging aesthetic and conceptual parameters that impinge on the practice of artists who consciously recognize data and coding as the primary expressions of an art practice?

This issue of the YLEM Journal looks to the writings of two artists whose practice conspicuously intersects with questions relating to the romantic and the sublime. Their writings, each in a different manner, suggest possible paths toward answering the many issues that have been raised by the explosion of, and our immersion in, big data. Interestingly, Andrea Polli's "Atmospherics/ Weather Works: Artistic Sonification of Meteorological Data" begins with a quotation from the romantic American poet Walt Whitman's "Proud Music of the Storm". Polli is interested in how sonification of large data sets differs aesthetically from visualization, and in helping a sonic "language or series of languages for communicating this mass of data needs to evolve." Not only does Polli's text clearly describe the types of aesthetic choices that were necessary in the sonification of the President's Day Snowstorm and Hurricane Bob data, but also reveals a successful example of interaction between and artist and scientist(s) to reinforce and potentially uncover new knowledge through what she claims is a potentially more visceral sonic experience of data.

YLEM Forum

"Sound Art"

Wednesday, September 8, 7:30 pm
McBean Theater, Exploratorium
3501 Lyon St., San Francisco, CA 94123

Free, open to the public and wheelchair accessible.

Since recorded sound became possible, technology has allowed sound to evolve beyond its fleeting existence. Technology and science have inspired sound artists to capture, generate and structure new experiences. Ever-evolving, sound art has introduced and combined sound and technology with several art forms to revolutionize the creative experience. Ambitious works may include sound, visual performance and/or installation

Video Game Sound and Synthpunk

Artist LX Rudis will talk about his techniques using the Oberheim Xpander and provide recorded and live examples. Credited as an early "synthpunk" performer, and an internationally recognized artist who has worked in all areas of development and production for both video game products and theater. LX's clients and collaborators include: Atari, Sega, Konami, SCEA [sony], Ultracade, George Coates Performance Works, SRL, Drum Machine Museum, Negativland, The Units and Winston Tong.

Sound Art and Technology

Randy H.Y. Yau, will discuss radical and compelling works that have influenced the genre of sound art. Yau is a curator, composer, sound artist and designer who has been active in the sonic arts since 1993. Yau founded and co-curates *Activating the Medium*, an annual sonic arts festival which travels through universities, museums and alternative art spaces across California including SFMOMA. He also founded Auscultare Research, a record label releasing sound works from international artists. He has conducted sound art radio programs for over 11 years and continues to broadcast on KPFA's "No Other Radio Network." Since 1999, Yau has served as the Curatorial Director of 23five Incorporated, a nonprofit sonic arts advocacy group based in San Francisco, and is currently its Executive Director.

Sound and Video

Artist Scott Arford will discuss the synaesthetia of his work in video and sound. Well-known for his sound and visual performances, fully immersive multichannel sound and video installations, and recently, low frequency spacial-acoustic explorations with Randy Yau.

The latter was with Infrasound, with Randy H.Y. Yau. Recently, Arford premiered solo works at SFMOMA in the Activating the Medium festival, and performed at the Australian Center for the Moving Image for Liquid Architecture. He has performed in Peru and The Netherlands, and taught a week-long sound workshop at the Center for Contemporary Arts in Kitakyushu, Japan. He also lectured last year at the San Francisco Performance Cinema Symposium.

Sound and Natural Phenomena

Artist Joe Colley will discuss possibilities of expanded listening and present a demonstration and listening exercise focused on amplified dried ceramic clay absorbing water. Joe Colley is a self-taught sound artist and amateur researcher investigating natural and manmade phenomena and their exploitation as source material for new forms of expression. His work under the name Crawl Unit has been released on numerous record labels worldwide. He also founded Povertech Industries, a record label releasing sound works from artists around the world. Colley has performed live and created installations throughout the United States and Japan.

Sound and Architecture

Artist Michael Gendreau will discuss his sound compositions and their correlation between his work in acoustic research and music. Gendreau has been a musician since age 6. He worked with several group organizations, and by age 22 founded, with Suzanne Dycus, Crawling With Tarts (1983-1998) He used this group as a medium for fascinating experiments in sound perception and composition. These final studies included the use of small motors and turntable mechanisms, mostly performing with one-off transcription discs cast by others in the middle of the last century, or cut in Gendreau's studio using a decrepit lathe. More recently, in composition and performance, Gendreau has sought to enlarge these later studies, adding physical parameters of performance spaces (based on studies in physics completed in 1989 and current work as an acoustician. He works primarily working on low-vibration design in buildings and noise impact on optical research apparatus).

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# The Prospect of the Sublime in Data Visualizations
by Lisa Jevbratt

The Polar Sea, Caspar David Friedrich 1823-1824

Looking out and up

In Caspar David Friedrich's (German, 1774-1840) "The Polar Sea" (1823-24) we look out on an endless inhospitable ocean of ice, and a shipwreck - a trace of an attempt to do the impossible, to go "there", to reach for and understand the unbearable void.
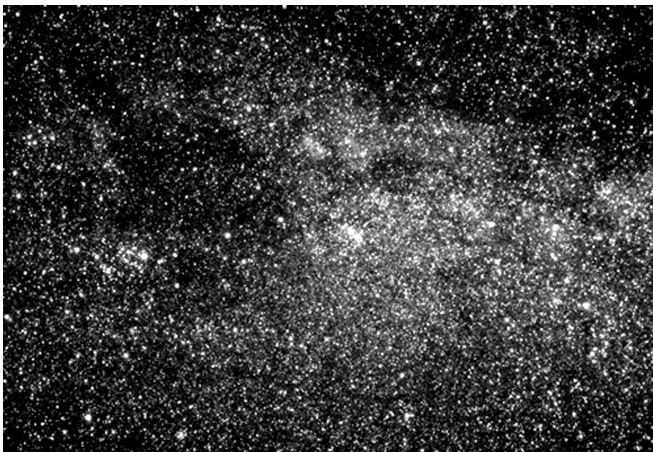
We look up at the starry sky and we sense a fear of not comprehending and being engulfed, a fear of the unknown, and simultaneously we experience a longing for the inaccessible, impenetrable darkness.

These are the classical visuals of the sublime. Images of a sense of grandeur we can't reach, which we can't penetrate or grasp. It is in the very far distant, it is hidden in layers of mist, or made inaccessible by a climate not suited for us and it instills a sensation of deep fear. Yet we urge for it, we are fascinated and attracted by it.

Starry Sky[1]

The Rocky Mountains, Colorado. Picture sixty-three taken with my new camera. 2004. Jevbratt.

Looking down and in

2004. We look down. We consume satellite and aerial photography in all its forms; on the web we can access detailed satellite and aerial photographs looking down on our houses or whatever we want to surveil from above, we are capturing mountains far below with our first digital camera, we have the poster of "lights emitted from the earth" on our walls (maybe pondering what it says to bypassing intelligences – gods, aliens and others), and we rely on satellite imagery to predict weather and track fires.

We look in. The genome is mapped and we are trying to figure out how to look at it. New technologies for looking in towards and inside cells, RNA and nano structures are rapidly developing, and the methods of making peripheral evidence of them and their processes are constantly refined. We look at our networks that produce data about ourselves in sublime quantities.
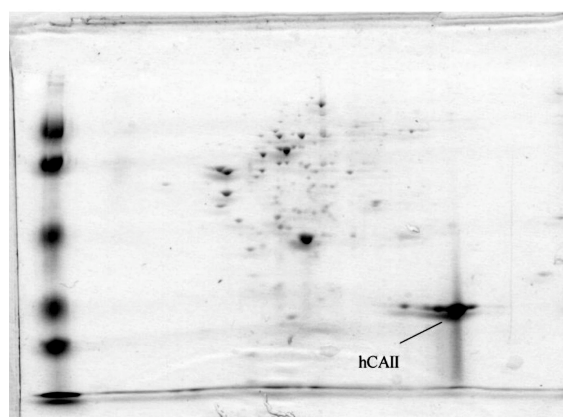

Peripheral evidence: two dimensional polyacrylamide gel.

Anti-Sublime

The datasets we are looking at now are of no less dimension, vastness and grandeur than the datasets that were the subject of the classical sublime; and the sensations of the sublime harvested by the romantic artist and others is of great interest to us when trying to make sense out of our datasets today. However, a quite logical argument against the possibility of the sublime acting within data visualization can be made. It has been well formulated by Lev Manovich in "The Anti-Sublime Ideal in Data Art".

> "If Romantic artists thought of certain phenomena and effects as un-representable, as something which goes beyond the limits of human senses and reason, data visualization artists target the exact opposite: to map such phenomena into a representation whose scale is comparable to the scales of human perception and cognition. For instance, Jevbratt's 1:1 reduces the cyberspace – usually imagined as vast and maybe even infinite – to a single image that fits within the browser frame."[2]
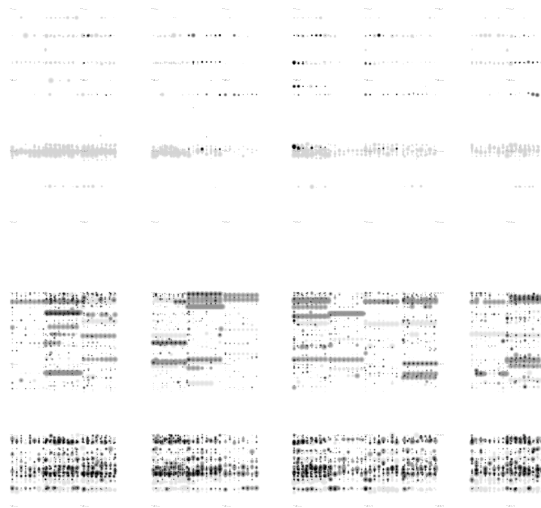
The entire Internet with The Web as it existed in 1999 (above) and 2002 (below). *1:1(2), Interface: Migration*, Lisa Jevbratt 2002[3]

The reasoning is very clear and it troubled me because I instinctively knew that it was wrong – both in making the case that data visualization by definition is anti-sublime and that my project 1:1 would be a good example of this case.

How then can data visualizations utilize the (or be) sublime? Why should they aim to?

Push, pull

While the datasets of today are as substantial as the ones dealt with in the classical romantic sublime, there is a difference in direction and force.

In the original sublime the force is attraction. The object of desire is over there, far away and we want to reach it. We want to go there, we are scared and intimidated but our longing and effort is 'towards'. When our force (engine, energy, luck) fails the ship stops, it does not get closer. The forces of nature push us away - we urge to approach. The classical sublime was the extreme tension of not knowing and wanting to know; we were attracted by the fact that we didn't know.

Now, looking in and down the force is reversed. If the engine in a plane stops, it approaches the ground; the natural force is gravity and we want to stay up and away. We are pulled down and respond by retracting. The forces of nature pull us down, in - we urge to repel. The sublime now is the extreme tension between (hypothetical) familiarity - the earth is our home, the cells and DNA are in our bodies, the networks are our creation - and a methodological distancing.

Esthetic decision-making

In the article "Systems Esthetics"[4] Jack Burnham wrote about the new complex process - or systems - oriented society, culture and economics he saw emerging: a new era in which systems analysis would be the most relevant method for making understandings in any discourse. Burnham argues that because we can't grasp all the details of our highly complex systems (economic, cultural, technical, etc), we cannot make "rational" decisions within them or understand them by analyzing the systems or their parts. The way to make decisions within them and to understand them is by making more intuitive, "esthetic decisions", a concept he borrows from the economist J. K. Galbraith.

This idea has an intriguing parallel in the philosopher Emmanuel Kant's reasoning about the mobilizing effect the sublime has on our organizing abilities. He claims that in experiencing the sublime, by facing large amounts of information, huge distances and ungraspable quantities, our senses and our organizing abilities are mobilized. Contrary to what might be believed, we feel empowered, able to make decisions, and capable to act.

Many strategies for aiding people in the task of turning any large set of data into knowledge assumes that they should be presented less information and fewer options in order to be able to make sense out of the data.

However, humans are capable of sorting through enormous amounts of visual information and making sensible and complex decisions in a split second, (the ability of driving a car is one example). Supported by Kant's idea I propose that under the right circumstances, drawing on sensations of the sublime, people can, when faced with huge quantities of data, be mobilized to make intuitive understandings of the data. Many information visualizations and displays are a result of the mistake of compressing the information too much and decreasing the amount of information through calculations that embody assumptions that are never explained. The most common mistake in data visualizations, artistic or scientific, is not too much information but too little. The "images" of the data landscape are not high resolution enough for an esthetic decision to be made.

Meaning is opportunistic

Why is low-resolution, highly-compressed data representation less meaningful? If it is counteractive to a sublime, why is that? How does that sense of awe and "aha" that the fear and force of the sublime helps us experience transpire?

Meaning behaves like a parasite. It is *opportunistic*, taking "immediate advantage, often unethically, of any circumstance of possible benefit" (the definition of opportunistic at http://dictionary.com). If meaning in fact is opportunistic, and opportunism implies an unethical stance, then it could follow that meaning does not thrive in an ethical environment. This reasoning is more interesting if one understands the term "ethic" as an opposition to "faith". "Ethic" is a stance in which one in any moment is aware of one's goals and choices. One has a plan and a way in which to carry it out. "Faith" is a stance in which we let go, were we are submerged and surrendered, when we are trustingly accepting a "truth", an emotion or a calling. (At the conference "Derrida and The Question of Religion" at UCSB in fall of 2003, Derrida mentioned during a discussion between him and a presenter the concept of *the calling* and reflected on how that concept is not that different from how animals follow traces. This constitutes an interesting point for the thoughts in this paper.)[5]

Culture then is extremely meaningless because so many choices have been made, and nature is extremely meaningful since no choices have been made. It seems like we strive to cut the extremes, the very meaningful and the extremely meaningless. To make culture more meaningful we create unstable conditions for decision making, i.e., to reduce the number of ready-made choices, we create unpredictable and arbitrary events and expressions within it. It is interesting to see that younger people are more prone to produce these. Quite likely a young mind has more difficulty dealing with the burden of meaninglessness, and thus tries to minimize it

by generating arbitrary signs (such as the expressions, fashion and sounds of various subcultures). To make nature less meaningful we organize and categorize it and our experiences of it. (Of course nature is only void of choices if one does not believe in a creating god. In fact the very idea of a creationist god could be seen as another attempt to decrease the meaningfulness of nature). However, another, contradictory reaction to nature might be that our ability to perceive meaning is numbed by the loudness of it. Just as our retina gets saturated after looking at one color and creates a ghost image of the opposite color when we look away briefly, nature can (falsely) appear as if completely void of meaning.

The result of this reasoning is that as soon as we are trying to make what we experience ethical, i.e. succumb to a plan and direction by making deliberate choices, the experience and its data decreases in meaning. If we semantically categorize and search for meaning, it is as if we try to look at the dust on our corneas - we can't see it unless we stop looking at it. Everything becomes meaningless when we attempt to "capture" the meaning. In the task of visualizing huge datasets this means that we need to avoid making assumptions about the meaning of the data in order to allow meaning to find an opportunity to occur. Perhaps the answer to the question in the beginning of this topic is that we need to allow the interplay between the extremes, allowing the meaningfulness and the meaningless to happen by not attempting to reduce either.

Identity in the non-intended

Some years ago a student of mine made an interesting discovery in a project he made[6] . It was Web software that returned the result of a search for something on a selection of search-engines in the reversed order, i.e., the most relevant, however the search-engines define that, was last on the list and the least relevant of the relevant sites was shown first on the list. The result was striking. The least relevant sites, the ones usually so many clicks away we don't bother to look at them, varied greatly between the different search engines. The most relevant results, the ones usually displayed on top, were all the same.

A similar finding was made some centuries earlier by Giovanni Morelli (1874-1876). He sought to find a method of determining authorship of paintings and came upon the fact that authorship is more detectable in the parts of a painting done with less intention - the parts which are not significant for the author or the genre in which the painting is made, such as earlobes and fingernails. His method is now called "The Morelli Method". In art historian Edgar Wind's words it is interesting that "Personality is found where personal effort is the weakest". [7]

Even more strikingly, what seemed to be true on the Web is also true in biology, according to Albert-Laszlo Barabasi in his book, *Linked: The New Science of Networks'.*[8] Barabasi is doing research on the network structures and linkage systems of various fields from computer networks to biology. He finds that "For the vast majority of organisms the ten most-connected molecules are the same." (p. 186) These highly connected molecules, hubs in Barbasi's terminology, are equivalent to the most relevant pages in a web search or the traditionally most "important" features in a painting. These are the items, nodes, with the most intent. Just as the least relevant web pages are the most dissimilar, and the least important features such as earlobes say more about the painter, the difference between different organisms and the production of their identity lies in the least-con-nected, least-used or significant molecules. "[O]nly four percent of the molecules appear in all of them. Though the hubs are identical, when it comes to the less connected molecules, all organisms have their own distinct varieties." (p. 187)

Via Negativa

These are all evidences that reality does not show itself to us in an expected manner, through intention and expression, but it reveals itself to us indirectly in small fragmentary pieces. The method of searching out those bits and pieces without preconceived notions of what to find has been an important method in various mystic traditions, and the term *Via Negativa,* possibly coined by Dionysius the Areopagite, a late 5th century mystic, is used to describe it. Via Negativa is a method of distancing, of negation, in which we claim or pretend to not have any preconceived notions of the systems that we are looking at. The method has a lot of similarity with artist methodologies (such as Joseph Beuys) and now also with some contemporary scientific methods.[9] For example, the process of harvesting, sequencing and map-ping the human genome has been described as that of a group of people in a dark room fumbling around not knowing what is in the room, how the room looks or what they are looking for. Someone bumps into a thing with four sharp corners and starts to look for other things with four sharp corners. Someone else decides to move along what seem to be walls and feel their texture, yet another sits still and waits for the others in the room to pass by, taking notes on their activities or maybe on their scents.

The value in Via Negativa for data visualization is that it creates that opposing force of not falling into a repelling force counteracting the gravity pulling us down. The Via Negativa enables the sublime to operate.

Epilog

Juno falling and snacking. Still from *Spy Kids 2: The Island of Lost Dreams*

If staying up is our (or others, things or beings) effort, then the fall, the ultimate inability to do so, is a trope of interest. There are significant falls ranging from literature, such as the fall of Alice, the girl in Wonderland, to political, such as the fall of the Twin Towers. In "Spy Kids 2: The Island of Lost Dreams", Carmen and Juni, the spy kids, fall into a model of the landscape, through the mouth of a volcano. Their fall lasts for an extended time, so long that they take comfortable positions, eat a snack and discus the possible outcomes of their fall. In the end they might not have been falling for a very long distance. The model that they are falling into has an air vent blowing air sufficiently strong for them to be lifted and they might have spent most of the time in the illusion of falling.

In a time period of eight weeks I experienced three events of falling substance that for one reason or another seemed to have significance. On a dreamlike evening just after sunset up on a mountaintop overlooking the beautiful cloud-covered southern Californian coastline far from above, a shooting star released itself from its usual celestial path, where we are accustomed to see it disappear far in the distance, and fell towards the earth and us as a real physical object on fire landing not too far away from us. A few weeks later I spent an hour in my closet attempting to clean up after a mold infestation that happened earlier in the year when I, more or less simultaneously, heard my neighbor flush her toilet and felt a liquid substance on my head. Three days into my artist residency in Huddersfield, Yorkshire, England, where I've taken refuge from the daily duties of teaching and meetings, an American bomb fell over Yorkshire; whatever the target was, it missed.

[1] Walter Koprolin, copyright © 2004 by Walter Koprolin, http://www.astro.univie.ac.at/~exgalak/koprolin/Photo/StarF/Cass_Per_50mm.html
[2] Manovich, Lev, "Data Visualisation as New Abstraction and Anti-Sublime",
also: http://www.chairetmetal.com/cm07/manovich-complet.htm
[3] http://jevbratt.com/1_to_1/
[4] Burnham Jack, *Artforum*, September 1968
[5] Jacques Derrida at "Derrida and the Question of Religion", UCSB, November 2003

[6] Gielow Ryan, San Jose State University, 1999
[7] Ginzburg Carlo, "Morelli, Freud and Sherlock Holmes: Clues and Scientific Method" in *History Workshop Journal*, 1980
[8] Barabasi Albert-Laszlo, *Linked: The New Science of Networks*, Perseus Pub, Cambridge Mass., 2002
[9] Gamwell, Lynn, *Exploring the Invisible: Art. Science, and the Spiritual*, Princeton University Press, 2002

Atmospherics/Weather Works: Artistic Sonification of Meteorological Data
by Andrea Polli
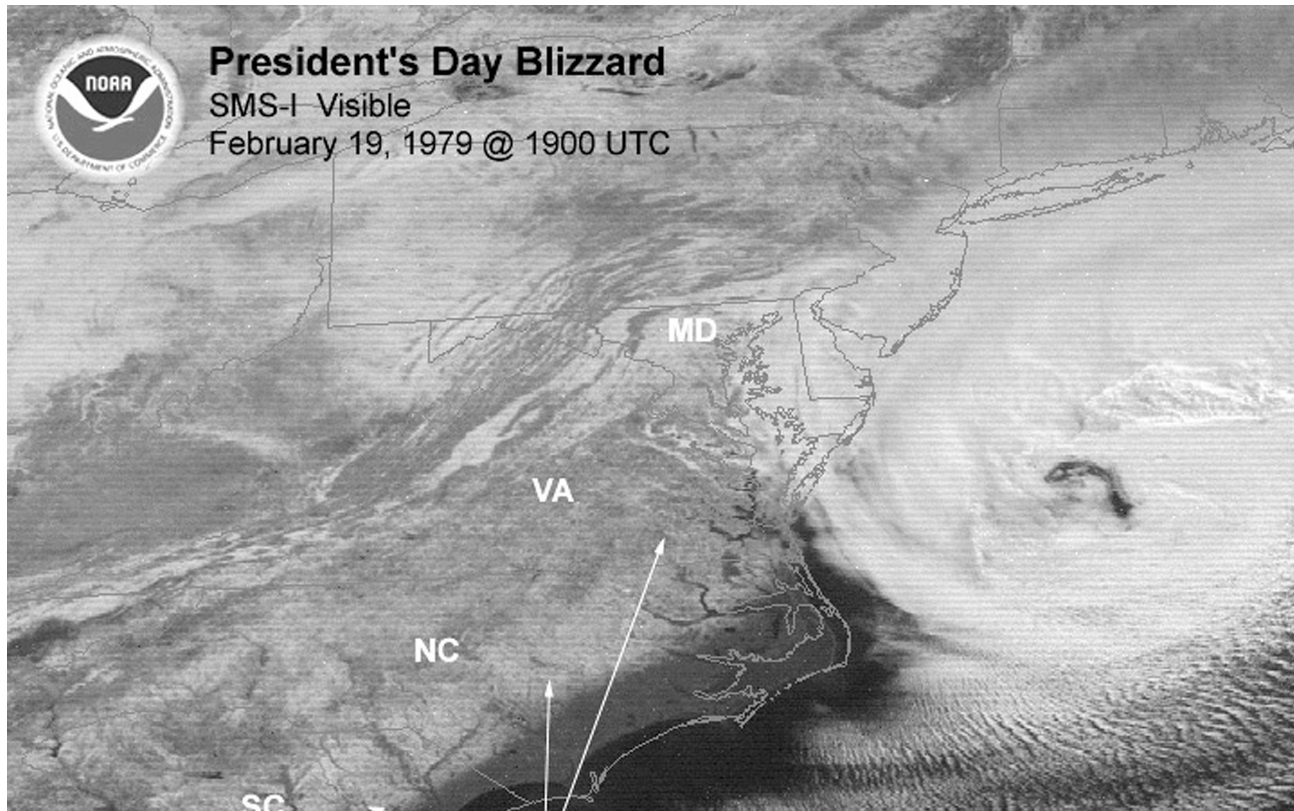
PROUD music of the storm!
Blast that careers so free, whistling across the prairies!
Strong hum of forest tree-tops! Wind of the mountains!
Personified dim shapes! you hidden orchestras!
You serenades of phantoms, with instruments alert,
Blending, with Nature's rhythmus, all the tongues of nations

Excerpt from Walt Whitman's "Proud Music of the Storm" [1]

Introduction

For over ten years, I have been creating art works that translate numerical data to sound, from algorithmic compositions modeling chaos to live improvisation using video analysis systems. Areas of particular interest to my research have been modeling human methods of improvisation in interactive computer systems and using data sonification to illustrate complex information. Visualization is the interpretation of scientific data through the visual image, and likewise sonification interprets data through sound. Sonifications can help scientific researchers understand data in a different way.

Since 2001, I have been working on the sonification of meteorological data in collaboration with Dr. Glenn Van Knowe at MESO, Mesoscale Environmental Simulations and Operations <http://www.meso.com> a leading firm in the development and application of atmospheric and other geo-physical models for research and real-time applications. MESO works with the Mesoscale Atmospheric Simulation System

(MASS) to create a highly detailed simulation of the weather based on terrain, initial conditions, and other factors. The atmospheric data sets produced by MESO are extremely detailed, and although they have a variety of visualization tools to interpret the data, much of the data represented is not visual in nature (temperature and atmospheric pressure for example). Through the project we wanted to learn what would happen if the data was interpreted sonically. In April 2003, we completed a series of multi-channel sonifications of two historical storms, a tropical hurricane and a winter snowstorm at five elevations as part of a storm sonification project called Atmospherics/Weather Works.

The Atmospherics/Weather Works project has three primary goals: the development of a software system for the creation of sonifications based on meteorological and other data to be used in performances and installations, live and recorded musical performances, and a web site for the presentation and distribution of the recordings and software. [2]

The first public installation of the project was in April, 2003 at Engine 27 <http://www.engine27.org>, a non-profit organization devoted to the research, creation and dissemination of multi-channel sound works in New York City. A 16-channel sound installation spatially re-creates

two historic storms that devastated the New York/Long Island area first through data, then through sound. The resulting turbulent and evocative compositions allowed listeners to experience geographically scaled events on a human scale and gain a deeper understanding of some of the more unpredictable complex rhythms and melodies of nature.

Why is scientific data so often presented as visual information and much less often presented as sound? One reason might have to do with time. A still visual image can be scanned over time, allowing a viewer to study various aspects of an image. A soundscape or piece of music, although it is also temporal, cannot be examined in detail without the destructive process of stopping, selecting, and replaying various parts. Aspects of the visual image are also easily defined by viewers. Specific colors and shapes can be described and understood more often than specific notes or musical phrases. Specific sounds also can have a level of ambiguity. Although some sounds are easily identified (like a barking dog or a cat's meow for example) the source of other sounds are not quite as clear. If noise or an echo interacts with a sound, it is like looking at a visual image wearing glasses that are heavily fogged, making recognition more difficult.

However, unlike a still visual image, music and soundscapes are inherently narrative. For example, as I listen to footsteps and voices outside my apartment door, I can determine that two people are walking up the stairs of my apartment building. I can determine approximately what floor they are on and even gather a little information about their relationship (are they a couple? a mother and child? have they been recently arguing or laughing?) In a visual image, a photograph of a family for example, unless the emotional states of the subjects are highly exaggerated, an observer is likely to encounter a certain amount of ambiguity in determining the relationships between the subjects.

Can an enhanced narrative and emotional content enhance the understanding of meteorological data? Some meteorologists call themselves "storm hunters". They travel far and wide at considerable physical risk in order to experience a hurricane or tornado. Is it because the physical and emotional exhilaration enhances the scientist's understanding of the storm? The storm hunters would most certainly answer in the affirmative. They experience the sound, scale, and physical properties of the storm as well as its direct effect on the environment. A storm experienced only through visualization, whether animated or static, does not convey this visceral information. Scientists must use their imagination to create a mental image of a storm's potential devastation. A sonic experience of a storm can benefit

communities beyond the meteorologist's lab. If a scientist is alerted by a visceral experience that a storm is likely to cause destruction, communities may be more quickly notified to prepare a proper response to the storm.

Our work represents a part of a growing movement in data sonification research. In 1997, The Sonification Report was prepared for the National Science Foundation by members of the International Community for Auditory Display (ICAD).[3] This report provides an overview of the current status of sonification research and proposes a research agenda. Most significantly to us as interdisciplinary collaborators, the report stressed the need for interdisciplinary research and interaction. Our project is well-suited to sonification according to the findings of ICAD. The data sets produced by MASS are extremely large and complex, and although there are a variety of visualization tools in use to interpret the data, much of the data represented is not visual in nature (temperature and atmospheric pressure for example). The data represented often portrays complex changes over time, an aspect of data particularly suited for sonification.

My personal interest in data sonification is in the artistic creation of new languages of data interpretation. As individuals and groups are faced with the interpretation of more and more large data sets, a language or series of languages for communicating this mass of data needs to evolve. Data interpreted as sound can communicate emotional content, and I am particularly interested in the sonification of data related to the atmosphere and the weather because of the long history of the weather used as a metaphor for emotion in the arts.

Project Planning

The project began when I met Dr. Van Knowe in the summer of 2001 at the first meeting of Bridges, an International Consortium on Collaboration in Art and Technology, a joint project of The USC Annenberg Center for Communication & The Banff Centre for the Arts New Media Institute [4]. Dr Van Knowe had joined MESO as a Senior Research Scientist after 24 years as a meteorologist for the Air Force. He was Chief of Meteorology at Rome Lab in New York where he directed the meteorological aspects of all research and was chief of the modeling and simulation development branch for the Air Force's Combat Climatology Center (AFCCC) at Scott AFB, IL.

Dr. Van Knowe and I brainstormed at that meeting and then continued to communicate via email and telephone to develop a project plan. After developing a proposal and being invited to participate in one of the first spatialized sound production residencies at Engine 27 to create a storm sonification, we met at MESO to plan the project.
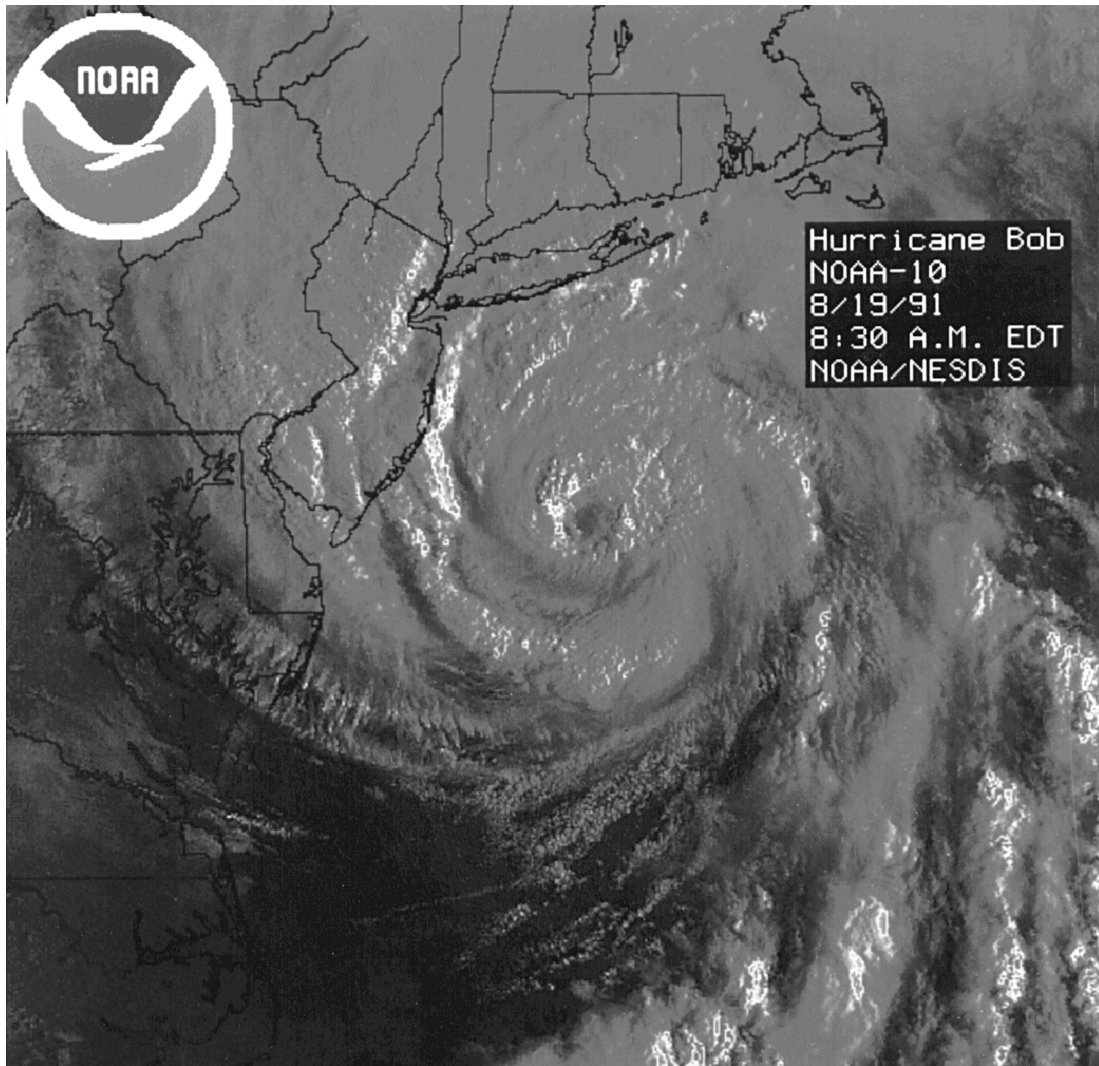
We wanted to create a spatial sonification of one or more storms that occurred in the New York area in the recent past in the hopes that some members of the audience would remember the specific storms.

Dr. Van Knowe and Dr. John Zack of MESO suggested we try to create a sonification of a major winter snowstorm that in 1979 was not foreseen by the existing meteorological models and inspired years of research and development into improving the models. The "President's Day Snowstorm" initially formed as a weak wave of surface low pressure on a front in the Gulf of Mexico on 18 February 1979. Since this storm was not predicted by the existing meteorological models of the time, a large amount of data on this storm was available.

Later, Dr Van Knowe found a strong tropical Hurricane, Hurricane Bob, that passed though the same coastal region. We decided to attempt to sonify two storms that have a very different physical structure to see if the

sonifications would yield insight into the nature of these two different types of storms.

Modeling the Storms for Spatialized Sound

Since the Engine 27 space has a very specific and unusual 16-channel speaker arrangement, we decided to map each speaker to a specific point in space proportional to the area spanning from Northern Florida to Northern New York State and from the Eastern tip of Massachusetts to Western New Jersey with New York City situated near the center. Simulated point data was to be modeled for an area of approximately 1000km. This area was mapped to the size and shape of the Engine 27 space.

The kind of model output needed for sonification was very different from the output formats already in use by MESO for visualization. Dr. Van Knowe and his colleagues use the Mesoscale Atmospheric Simulation System (MASS) to create a highly detailed simulation of the weather based on

terrain, initial conditions, and other factors. MASS takes real data inputs from satellite or surface readings and couples the information with global and regional models.

There are several MASS output file formats: 3D array files, 2D horizontal (x-y plane) files, 2D vertical cross sections (x-z plane), 1D x,y simulated point observations, and 1D vertical profile (x,z) simulated point atmospheric soundings.

Our project required files of individual variables output for each geographical point at regular temporal intervals. Dr. Van Knowe and Dr. Kenneth Waight of MESO created a custom piece of software to output the data in this format. Kenneth T. Waight joined MESO in October 1987 after completing his Ph.D. in atmospheric science at the University of Wyoming. His first three years at MESO were spent on a project funded by the NASA Marshall Space Flight Center. Dr. Waight relocated to MESO's Troy, New York office in 1990 to assist in the development of MESO's real-time operational mesoscale modeling system.

Dr. Van Knowe then created a complete model of each storm at 5 points of elevation: sea level, approximately 8500 feet, approximately 18,000 feet, approximately 35,000 feet, and approximately 60,000 feet (or, the top of the atmosphere). Each variable was output every three minutes for a 24 hour period of the greatest storm activity. The model grid resolution was 10km. Nine variables were modeled at this stage, but only six variables were used in the final sound compositions: atmospheric pressure, water vapor, relative humidity, dew point, temperature, and total wind speed.

Overall model area for the data output
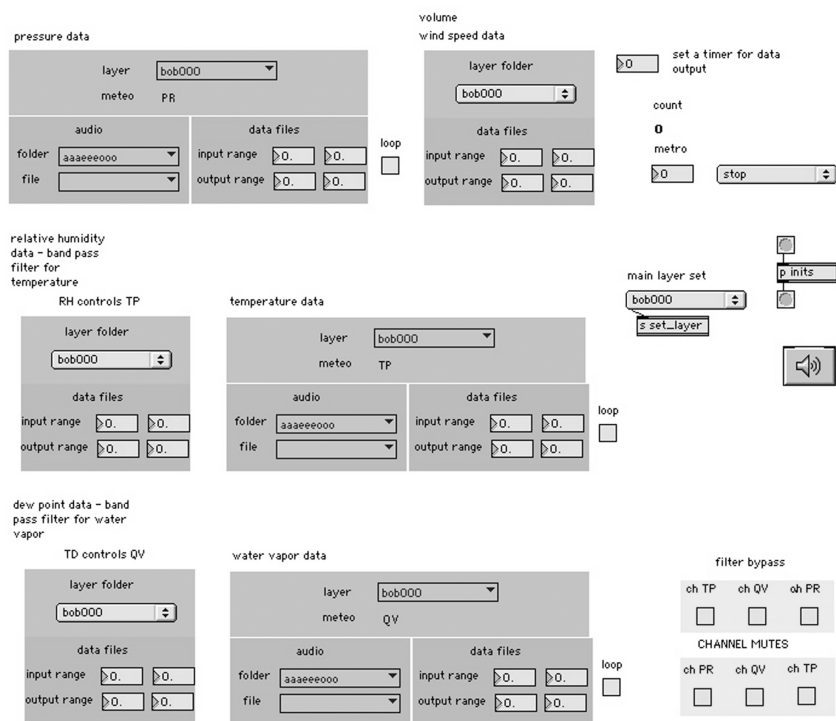
Top level of the Max/MSP patch used to run the multichannel system at Engine27
(patch designed by Matthew Ostrowski)

Creating the Sonifications

After the storms were modeled and the data output, we were left with 720 data files of 481 values each and the daunting task of translating these numbers into sound. Engine 27 master programmer Matthew Ostrowski joined us at this stage and he and I worked at the Engine 27 space for a period of about four weeks creating a system for reading and translating the files to spatialized sound using Max/MSP.

We decided to create a composition of each day's storm activity in full at each of the five elevations. We started by simply and directly mapping each variable to the pitch of a sound sample of a distinct timbre. We somewhat arbitrarily used long tones for temperature and pressure related variables and percussive tones for water related variables. The bank of sound samples used included vocal sounds, sounds created by wind instruments, and environmental sounds including the sounds created by various insects. The resulting sound compositions were interesting, but listeners found it difficult to hear the changes in each individual variable.

We then decided to map the total wind speed to the amplitude of the sound. Directly mapping loudness to wind speed for every speaker (every geographic point) created a dramatic spatialization effect. The fastest wind

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speeds, representing the greatest storm activity, created the most sonic activity and excitement.

However, the combination of timbres was still overwhelming to the listener, limiting the listener's ability to make sense of the data. At this point, we decided not to limit the number of variables presented through the sonification for the sake of the public presentation. Had we been creating the sonifications for research only, at this stage we might have brought Dr. Van Knowe and his colleagues into the space to listen to and compare and contrast sound compositions created by single variables. However, there was a deadline for a public presentation of the work to a general audience and aesthetically we felt that the single variable compositions lacked the fullness necessary to engage a general audience expecting to hear a musical composition.

The first aesthetic choice was to translate the atmospheric pressure data to a very low frequency sound. In doing so, listeners lost the ability to hear a detailed melody line describing the pressure changes, but gained a visceral sense of the storm.

Then, we began experimenting with using some of the variables as filter variables for sound samples representing other variables. Some of the variables in the model were highly coupled or inversely related to other variables. We created a band-pass filter that filtered a sound representing temperature with dew point values and filtered water vapor with relative humidity values. We found at this point that we needed to choose sounds with a wide spectrum in order to hear the filtering most effectively. White noise has the widest spectrum, and selecting 'noisy' sound samples proved the most effective in communicating the data and also was the most effective aesthetically due to the variation in the resulting sounds.

The scaling of the data for sonification presented particular challenges. Although the overall wind speeds varied with elevation levels, we decided to use global scaling for wind speed. This created the effect of the compositions building and receding in intensity. However, using global scaling for variables such as temperature mapped to pitch or water vapor mapped to a band pass filter proved to be much less dramatic than creating a scaling system for each elevation level of each storm since the variables differed widely between levels.

Finally, since the sonifications were to be performed in the format of a spatialized sound installation, we developed a daily schedule in which various compositions present the data sets at the five elevations, moving from ground level to the top of the atmosphere. In the installation, each storm was performed for approximately 1/2 hour six times each day. A storm consisted of six approximately five minute compositions presenting all variables at a single elevation and one combination of elevations based on the heights of the speakers. These compositions were marked by a number of ringing bell sounds, marking time and elevation like the ringing of church bells.

Conclusion

The final compositions were well received by both the general and the scientific audiences. Visitors to the installation particularly enjoyed remembering where they were during Hurricane Bob and the President's Day snowstorm while listening to the sonifications. Some audience members found a metaphorical meaning in the series of rising elevations, finding the compositions nearer to the ground to be more visceral while those compositions representing activity closer to the top of the atmosphere were felt to be more ethereal and spiritual.

Dr. Van Knowe was particularly intrigued by the spatialization of the sound, and was interested in how the wave patterns of the storms were moving in space. The sonifications reinforced some known aspects of the particular storms. The winter storm was more intense near the top of the atmosphere while the hurricane's fastest wind speeds occurred at lower elevations. This change in intensity was communicated very clearly through the varying degrees of loudness of the compositions. The patterns of movement of the tropical hurricane were known to be more chaotic than the winter storm, and the resulting compositions also reinforced this concept. Most listeners found that they could understand more the more they listened to the compositions, and there was an overall consensus that the work opens up doors for more research both in science and the arts.

[1] Murphy, Francis. Ed. "Proud Music of the Storm" from Walt Whitman: The Complete Poems New York: Viking Press; Reprint edition, 1990.
[2] Polli, Andrea, and Van Knowe, Glenn, *Atmospherics/Weather Works: The Sonification of Meteorological Data.* 2003. /studio/atmospherics
[3] Kramer, Gregory et. al, *The Sonification Report: Status of the Field and Research Agenda*, 1997. Available from http://www.icad.org/websiteV2.0/references/nsf.html
[4] The USC Annenberg Center for Communication & The Banff Centre for the Arts New Media Institute, *Bridges: International Consortium on Collaboration in Art and Technology*, 2001.

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In a related article which was originally intended to be published alongside the articles in this issue, (see YLEM Journal Volume 24 Number 6, May-June 2004), Christina McPhee discusses data sonification "Sense of Place and Sonic Topologies: Towards a Telemimetic Sublime in the Data Landscape". Polli and McPhee share an interest in data sonification and collaboration with science, but it is especially interesting that they also meet up in something of a rapprochement with the romantic tradition that Manovich discusses. Polli's notion of how data sonification might lend to a "physical and emotional exhilaration [that] enhances the scientist's understanding" is congruent with McPhee's notion that "...one may turn a gaze to what cannot be 'seen'. Here we move into a zone of the sublime." In an abstract sense, it is the same matter of scale that the romantics faced via exposure to a new, often breathtaking landscape (during the period of colonialist expansion in previous centuries), that is today expressed technically as a matter of scaling systems of processing as humanity is faced by the expansion of scientific data. The current context reactivates the sublime as an issue for contemporary artists working with large data sets.

It should be noted that this rapprochement with the romantic and the sublime is in no way a conservative one. The sublime, which can also be described as a particularly human cognitive response to decision-making circum-stances wherein the amount of data overwhelms one's deductive reasoning capabilities, yet under which humans are more often than not able to think and act to yield successful outcomes, is one of the general capabilities to date that has evaded machine intelligence. It seems that the prodigious deductive abilities of computational systems can not yet simulate the prodigious inferential capabilities of the human mind. We have not yet entered the period of strong AI predicted in JCR Licklider's 1960 essay "Hu-man-Computer Symbiosis", but rather we continue to exist in the symbiotic phase where "Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man, and men can do readily and well, though not very rapidly, many things that are difficult or impossible for computers."[2] Big data, as it turns out, is a challenge even to this successful symbiosis, and the work of both Polli and McPhee can be read as attempts to engage the human capability to experience the sublime as part of the process of understanding big data. The sublime is something that people can participate in readily and well, and exploring how that capability might assist the human drive to develop and refine knowledge is some-thing that artists are presently working through, in practice and theory.

Lisa Jevbratt's "A Prospect of the Sublime in Data Visualizations", is both an attempt to theorize the contem-porary situation regarding artists and the sublime in a theorizing mode, and an answer to Manovich's use of her work as an example of the anti-sublime ideal. In her essay, she explores the potential for a symbiotic human-machine space to be understood via the sublime in terms of a "methodological distancing" including the concept of "Via Negativa" and a proper appreciation of the opportunistic nature of meaning that would allow us to take into account (romantic) philosopher Emmanuel Kant's notion regarding the "mobilizing effect the sublime has on our organizing abilities." Jevbratt thinks this would help us avoid "The most common mistake in data visualizations...", that being "not too much information but too little, their 'images' of the data landscape are not high resolution enough for an esthetic decision to be made."

On behalf of the *YLEM Journal's* executive editor, Loren Means, and the YLEM board, and the journal *Scale* (http://scale.ucsd.edu) which is publishing the larger collection of essays online (with the addition of a republication of my earlier essay "Software Development Platforms for Large Datasets: Artists at the API", originally in *Leonardo Electronic Almanac* volume 11, number 5, May 2003 ISSN #1071-4391), I hope that these writings will help further define the problem of the sublime and big data, and stimulate further discussion of the issues and opportunities presented to artists by the problem of big data generally.

[1] Manovich, Lev The Anti-Sublime Ideal in Data Art, (2002) http://www.manovich.net/DOCS/data_art.doc
[2] Licklider, JCR, Man-Computer Symbiosis, original publication 1960, reprinted in The New Media Reader, ed. Noah Wardrip-Fruin and Nick Montfort, MIT Press, Cambridge Massachusetts/London England, 2003. (77)

ERRATUM:

YLEM Journal Executive Editor Loren Means received this error report from Australian science fiction writer and critic Damien Broderick: "The caption for the cover art on Mar/Apr 2004 shouldn't read: 'My Conception of Paul Anderson's Tao Zero' but rather 'My Conception of Poul Anderson's Tau Zero'. Then again, I rather like the idea of Tao Zero and might steal it for a story or article title... :)"

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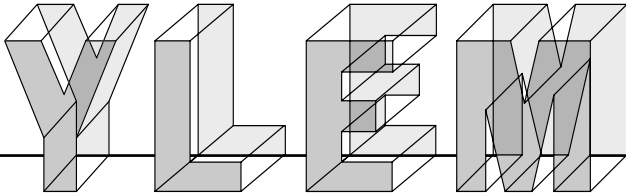
n. pronounced eylum, 1. a Greek word for the exploding mass from which the universe emerged.

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